REMARKS

Claims 1 and 3-14 are pending in this application. By this Amendment, Applicants amend claims 1 and 9, cancel claim 2 and add new claim 14.

Applicants respectfully submit that Figs. 6 and 9 and the corresponding disclosure in the specification, as originally filed, disclose and provide proper support for the features recited in new claim 14. Thus, no new matter is introduced by new Claim 14. Accordingly, Applicants respectfully request entry and consideration of Claim 14.

The drawings were objected to because Figs. 22A-26 were not designated as --PRIOR ART--. Applicants have amended Figs. 22A-26 in the accompanying Request for Approval of Drawing Corrections to be properly labeled as --PRIOR ART--. Additionally, Applicants have amended Figs. 6 and 9 to correct the highlighted area to be consistent with the specification, as originally filed. No new matter has been added by the amendments to the drawings. Accordingly, Applicants respectfully request reconsideration and withdrawal of this objection.

Claims 1-13 were rejected under 35 U.S.C. § 102(b) as being clearly anticipated by Kadota ("Combination of ZnO Film and Quartz to Realize Large Coupling Factor and Excellent Temperature Coefficient for SAW Devices"). Applicants respectfully traverse this rejection.

Claim 1 has been amended to recite:

> "A surface acoustic wave device, comprising:
> a quartz substrate;
> a piezoelectric thin film disposed on said quartz substrate;
> **comb electrodes disposed between said quartz substrate and said piezoelectric thin film**; and
> **the normalized film thickness H/λ of said piezoelectric thin film is at least about 0.20, wherein the film thickness of said piezoelectric thin film is H, and the wavelength of a surface acoustic wave is λ.**"
> (Emphasis added)

Claims 9 and 14 recite features that are similar to the features recited in Claim 1, including the emphasized features.

In conventional ZnO/IDT/Quartz surface acoustic wave devices, the normalized film thickness (H/λ) of the piezoelectric ZnO thin film has been limited to 0.10 or less

(see curve highlighted in red in the enclosed copy of page 264 of Kadota). With the normalized film thickness being 0.10 or less, the electromechanical coupling factor k^2 is very low.

However, the inventors of the present invention have discovered that by increasing the normalized film thickness (H/λ) of the piezoelectric thin film in a ZnO/IDT/Quartz surface acoustic wave device to be at least about 0.20, the electromechanical coupling factor k^2 is greatly improved.

The Examiner alleged that Kadota et al. teaches all of the features recited in claim 1. Applicants respectfully disagree.

In contrast to the present claimed invention and the Examiner's allegations, Fig. 3 of Kadota teaches that the normalized film thickness (H/λ) of the piezoelectric thin film (ZnO) of a ZnO/IDT/Quartz surface acoustic wave device is limited to about 0.10 or less (see highlighted curved in the enclosed copy of page 264 of Kadota). Thus, Kadota et al. clearly fails to teach or suggest "the normalized film thickness H/λ of said piezoelectric thin film is at least about 0.20, wherein the film thickness of said piezoelectric thin film is H, and the wavelength of a surface acoustic wave is λ" as recited in the present claimed invention.

In fact, Kadota teaches away from the claimed invention because the normalized film thickness of the piezoelectric thin film (ZnO) is clearly limited to about 0.10 or less. It is error to find obviousness where references diverge and teach away from the invention at hand. W.L. Gore & Assoc. v. Garlock Inc., 721 F .2d 1540, 1550, 220 USPQ 303, 311 (Fed. Cir. 1983).

It appears that the Examiner has completely misinterpreted Fig. 3 of Kadota. Particularly, the two additional solid-line curves in Fig. 3 (other than the ZnO/IDT/Quartz curve highlighted in red in the enclosed copy of page 264 of Kadota) are directed to Rayleigh surface acoustic wave devices having entirely different configurations from those of the present claimed invention. These additional solid-line curves in Fig. 3 of Kadota are directed to an IDT/nZnO/Quartz and an IDT/ZnO/Quartz surface acoustic wave device. In other words, the two additional solid-line curves are directed to surface acoustic wave devices including **a piezoelectric thin film** disposed between a quartz

substrate and comb electrodes, **NOT** to a surface acoustic wave device including "**comb electrodes** disposed between said quartz substrate and said piezoelectric thin film" (emphasis added) as recited in the present claimed invention.

Accordingly, Applicants respectfully submit that Kadota fails to teach or suggest the unique combination and arrangement of elements recited in claims 1, 9 and 14 of the present application.

In view of the foregoing Amendments and Remarks, Applicants respectfully submit that Claims 1, 9 and 14 are allowable over the prior art for the reasons described above. Claims 3-8 and 10-13 are dependent upon claim 1, and are therefore allowable for at least the reasons that claim 1 is allowable.

In view of the foregoing Remarks, Applicants respectfully submit that this Application is in condition for allowance. Favorable consideration and prompt allowance are respectfully solicited.

The Commissioner is authorized to charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 50-1353.

Respectfully submitted,

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VERSION WITH MARKINGS SHOWING CHANGE MADE

1. A surface acoustic wave device, comprising:

a quartz substrate;

a piezoelectric thin film disposed on said quartz substrate;

comb electrodes disposed between said quartz substrate and said piezoelectric thin film; and

the normalized film thickness H/λ of said piezoelectric thin film is at least about [0.05] 0.20, wherein the film thickness of said piezoelectric thin film is H, and the wavelength of a surface acoustic wave is λ.

9. A surface acoustic wave device [in accordance with claim 1,] comprising:

a quartz substrate;

a piezoelectric thin film disposed on said quartz substrate;

comb electrodes disposed between said quartz substrate and said piezoelectric thin film; and

the normalized film thickness H/λ of said piezoelectric thin film is at least about 0.20, wherein the film thickness of said piezoelectric thin film is H, and the wavelength of a surface acoustic wave is λ; wherein

the Euler angles of said quartz substrate are within the range such that the power flow angle PFA of a Rayleigh wave is within about ± 2.5°; and

the Euler angles of said quartz substrate are within the range such that the electromechanical coupling coefficient for a spurious wave K_{sp}^2 is not larger than about 0.1%.

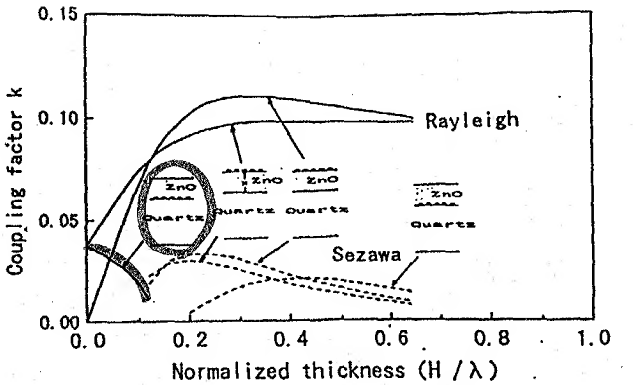

Fig. 3. ZnO thickness dependence of calculated electromechanical coupling factor(solid line: Rayleigh SAW, broken line: Sezawa SAW).

IV. Experimental Results of Velocity and Coupling factor

After deposition of a ZnO film to a thickness of 4.5~7 μm on the 29°45'rot.Y and 42°45'rot.Y quartz substrates by an RF magnetron mode electron cyclotron resonance (RF-MG-ECR) or a conventional RF magnetron (Con. RF-MG.) sputtering system, aluminum IDTs were formed on the ZnO film by a liftoff method to provide the above-mentioned structure of (a)IDT/ZnO/quartz. A SAW filter consists of two normal-type IDTs having 20 pairs having various wavelengths of 13~72μm. It was found from X-ray diffraction analysis that the ZnO film formed on these quartzes was a poly-crystal c-axis oriented film.

dependence of the velocity and the electromechanical coupling factor on ZnO film thickness are shown in Figs. 4 and 5. In both figures, theoretical values for the ZnO on the 29°45'rot.Y35°X and 42°45'rot.Y35°X quartz substrates are shown by solid lines and broken lines respectively. Measured values for ZnO/29°45'rot.Y and 42°45'rot.Y quartz substrates deposited by the RF-Mg-ECR sputtering systems are plotted as ∘ and • and those deposited by the Con. RF-MG. sputtering systems as × and +, respectively. In these figures, the measurement results are only Rayleigh SAWs. Though Sezawa SAWs exists theoretically, no generation of Sezawa SAWs could be observed because of their small coupling factor. A slight difference was observed with respect to the velocity of the thin ZnO film deposited by the RF-MG-ECR between the theoretical values and the experimental values ; however, with respect to the other velocities and the coupling factors, these values agreed well. In the range of ZnO film thickness H/λ from 0.2 to 1.0, large values of electromechanical coupling factors (0.1~0.11) are obtained which are identical to the theoretical values. The coupling factor values of the 29°45'rot.Y plate and the 42°45'rot.Y plate are almost identical, both experimentally and theoretically. The structure of (c)IDT/ZnO/shorted-plane/quartz also is considered to be able to provide a large value approximately identical to the theoretical value as in the case of the structure of (a)IDT/ZnO/quartz. Where the SAW velocity was obtained from the center frequency of the SAW filter and the wavelength. The electromechanical coupling factor was determined by measurement of a radiation conductance of a motional conductance circle of the above-mentioned normal IDT [5], [16], [17], [18]. Residual inductance in the measurement (for example, generated from a measuring jig or a sample) affects the measured motional conductance. As residual inductance in the measurement increases, the motional conductance circle moves away from the susceptance axis, its trajectory becomes tilted, and the motional conductance becomes large [5], [16], [17]. It is necessary to measure the radiation conductance under the condition of minimum residual inductance for accurate coupling factor determination [5], [16], [17]. It is possible to evaluate a accuracy in the measurement from the tilt of the trajectory of the motional circle.

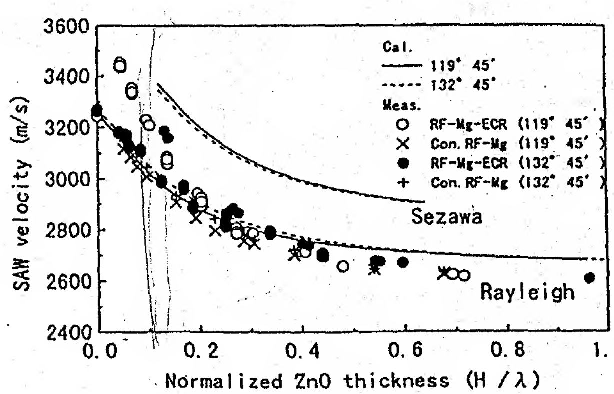

Fig. 4. SAW velocity relative to ZnO thickness.

V. Experimental Results of TCF

The center frequencies of the SAW filters were measured at temperatures from −20 to 80°C. The results for a SAW filter on IDT/ZnO/29°45'rot.Y35°X quartz are indicated for a ZnO thickness $H/\lambda \doteq 0 \sim 0.54$ in Fig. 6 as a function of temperature. In this figure, the ZnO films were deposited by the Conventional RF-MG. sputtering system. Measured values of the TCF in the absence of a ZnO film are plotted as ∘. Measured values for ZnO film thicknesses H/λ = 0.10, 0.29, 0.38 and 0.54 are indicated by △, ×, • and ⋄, respectively. It is clear that as a result of deposition of the ZnO with a negative TCF on the quartz having a positive TCF,